Mediterranean High-Frequency radar network:
regional coordinated efforts meeting end users and science-driven requirements

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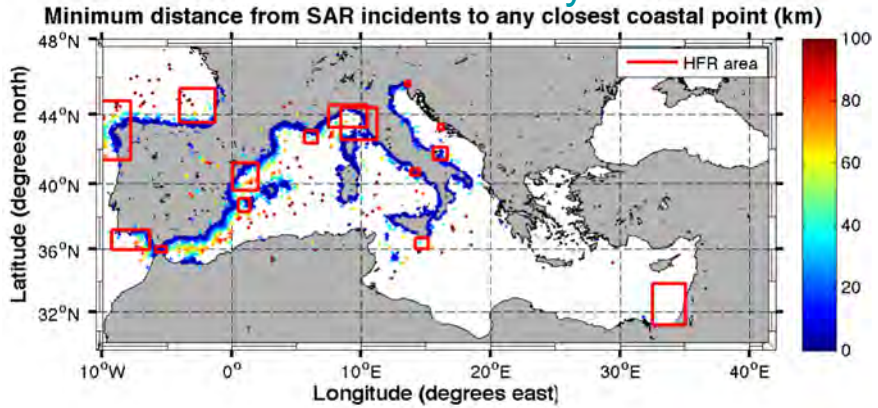
The Mediterranean coastal areas

Maritime Safety

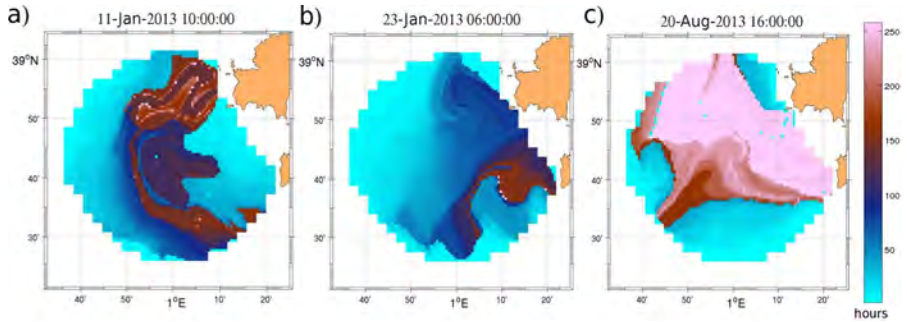


SAR incidents locations from France, Italy, Slovenia and Spain in 2019

Extreme Hazards

Ebro Delta before and after Gloria storm in January 2020 (Lorente et al., 2021)

Environmental Transport Processes

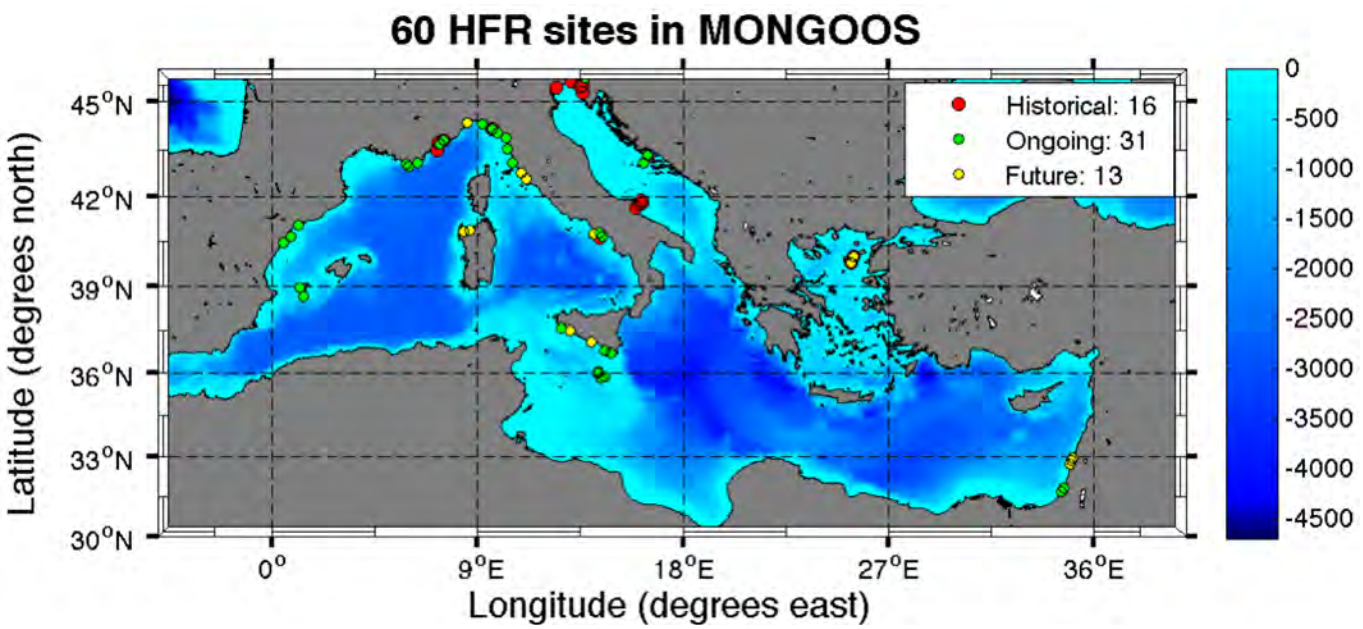


Particle residence times (hours) from HFR-Ibiza (Rubio et al., 2020)

Integration of HFRs in the COOSs

- Cost-effective land-based technology
- Operation principle: Bragg's theory
- 2D surface currents maps, waves & wind
- High spatial resolution (0.2- 6 km)
- High temporal resolution (30'-1h)
- Wide coastal coverage (> 200 km)
- Complement coastal in-situ & satellite

MONGOOS HFR network: status

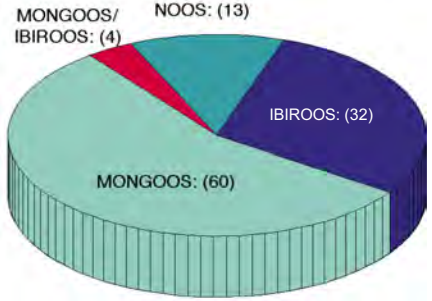


Map of HF radar systems (> 55% in EU) deployed in the Mediterranean

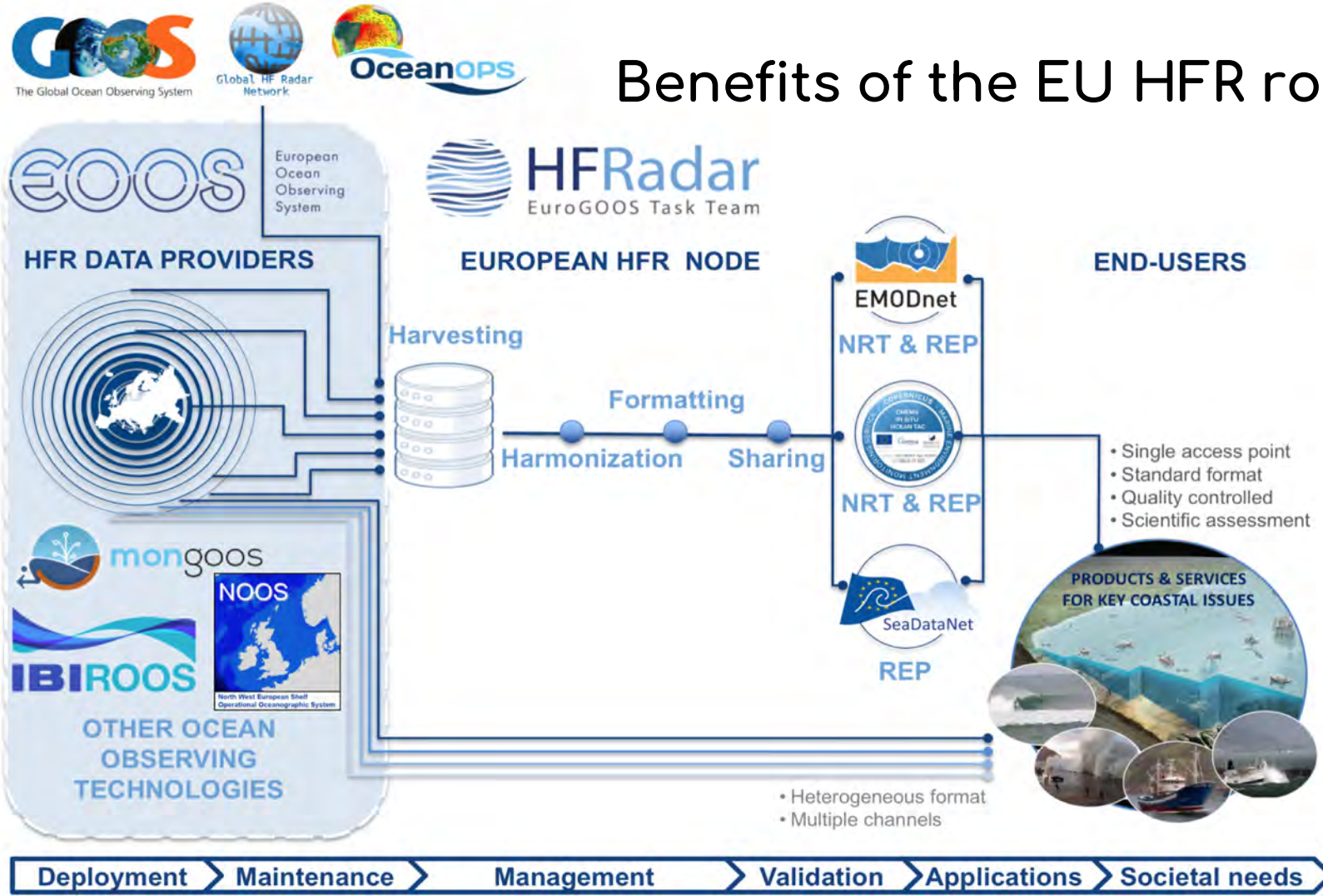
(from the last updated EU HFR network inventory, March 2021)

Going into detail...

- 21 networks (> 48.8% of EU)
- 60 HFR sites (55.04% of EU)
- 49 HFR permanent (81.6%)
- 31 HFR ongoing (51.7 %)
- 13 Future HFR (21.6 %)
- 33 medium-range (55%)
- 14 NRT connected (23.3%)
- 9 REP connected (15%)
- Unbalanced N/S and W/E



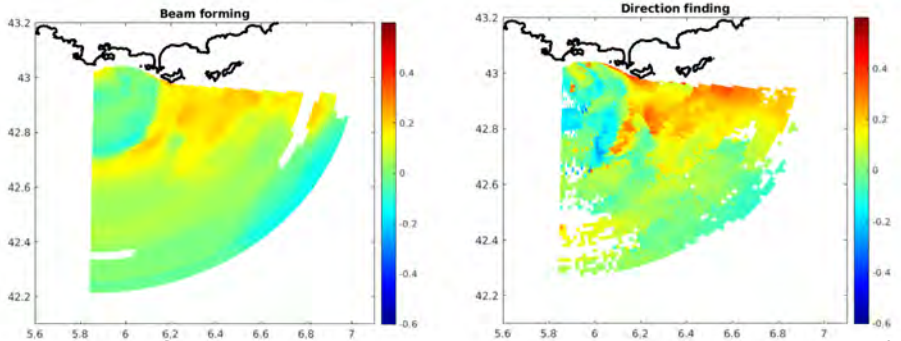
Benefits of the EU HFR roadmap



HFRs Basic Products

Surface Currents

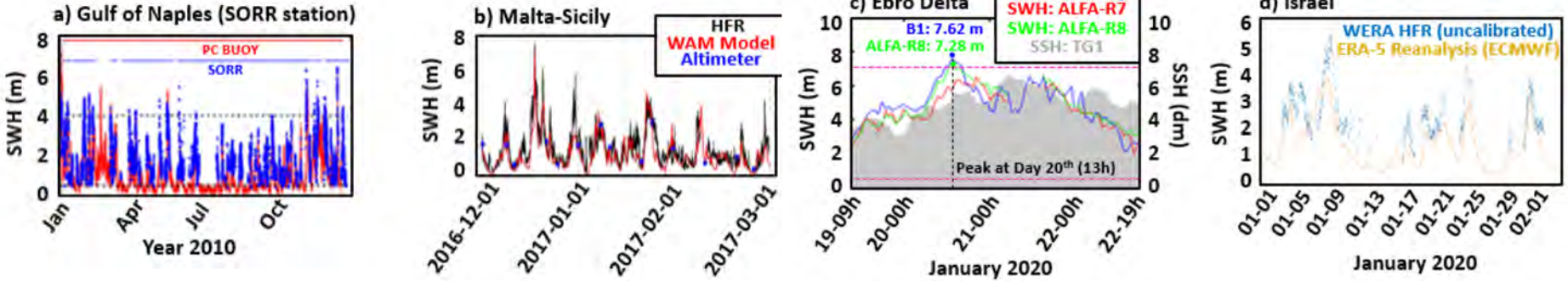
- Primary HFR measurement
- First-order Bragg peaks
- Different factors can affect the radial currents measurements
- New techniques to improve raw HFR signal processing quality



Hourly radial surface current maps provided by HFR in Fort Peyras (Toulon, France) with a 12-antenna receiving array. Dumas and Guérin, 2020

Wave height, period and direction

- Second-order Bragg peaks
- Reliable source of wave information >> useful for early warning systems



Time series of the validation of HFR derived Significant Wave Height (SWH) versus: a) PC buoy (in the GoN); b) WAM model and altimeter (in Malta-Sicily Channel); c) buoy (Ebro Delta); d) ERA-5 reanalysis (Israel)

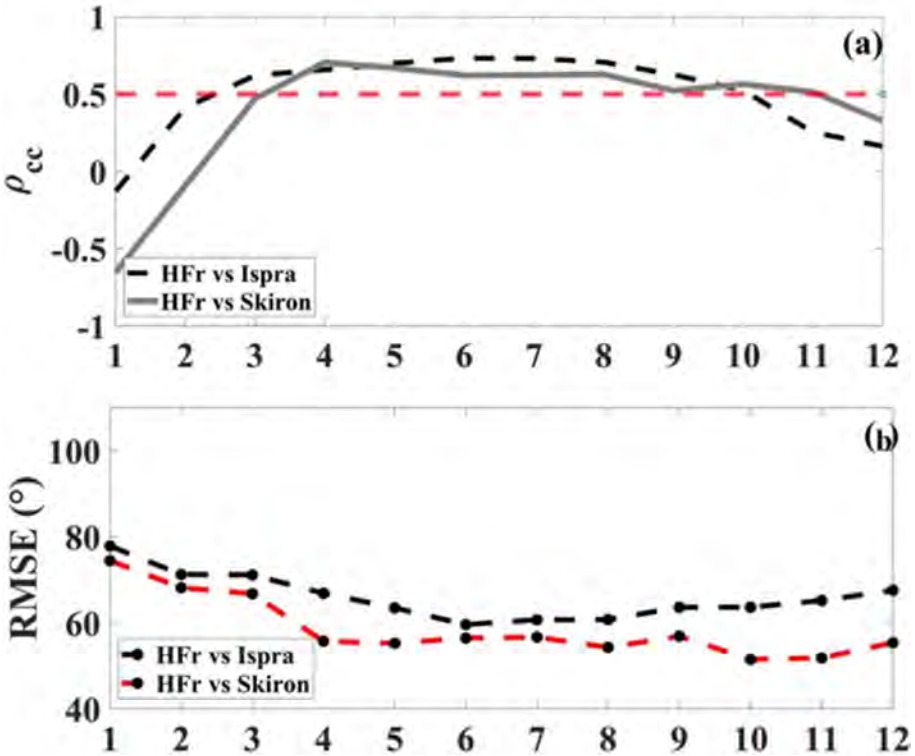
HFRs Basic Products

Winds

2 studies in the Mediterranean Sea

- Ligurian Sea: WERA radar, 12 MHz (Shen & Gurgel, 2018)
  - Wind direction accuracy depends on the HFR frequency
  - Inversion of wind direction improves with higher-wind conditions

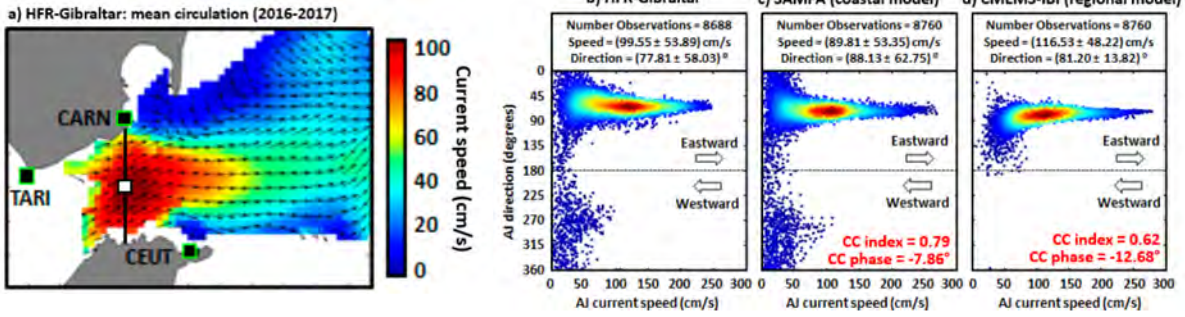
- Gulf of Naples: CODAR SeaSonde HFR, 25 MHz (Saviano et al., 2021)
  - Validation vs. weather station and SKIRON/Eta model
  - Good statistical agreement, better between 4-10 km from the coast
  - Noise interference, wind duration and fetch should be evaluated.



Variation of the (a) circular correlation coefficient and of the (b) RMSE on range cells between HF radar wind direction versus the weather station (located at Ispra) and the model SKIRON/Eta for February 2009 in the Gulf of Naples. Saviano et al., 2021

HFR Applications: Maritime Safety

Model assessment & improvement

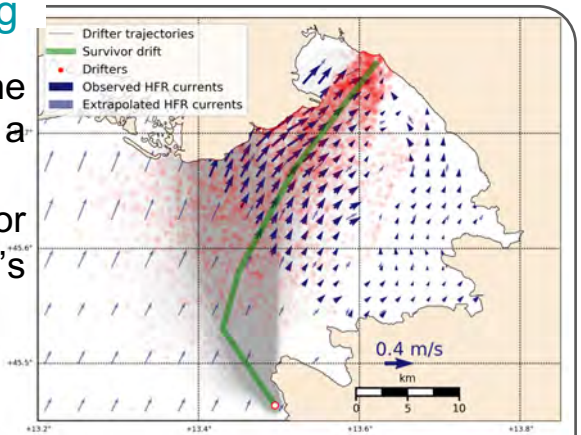


CMEMS-IBI and SAMPA coastal model assessment vs. HFR-Gibraltar in 2017 (Lorente et al., 2019)

- The assimilation of HFR currents helps to reduce the error in simulating trajectories up to 50% (Hernández-Lasheras et al., 2021)

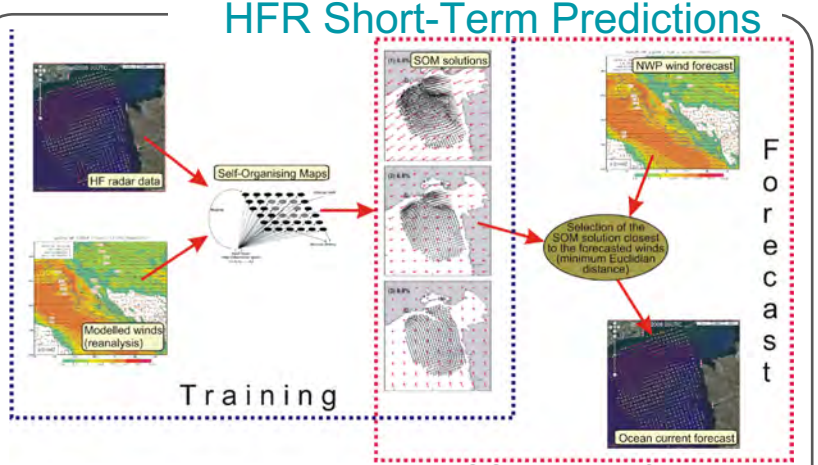
Lagrangian hindcasting

- SAR operation in the Northern Adriatic during a Scirocco storm.
- HFR-NAdr employed for hindcasting & survivor's drift trajectory verification.



HFR currents for Lagrangian hindcasting of an accident in October 2018 in the Gulf of Trieste (Ličer et al., 2020)

HFR Short-Term Predictions

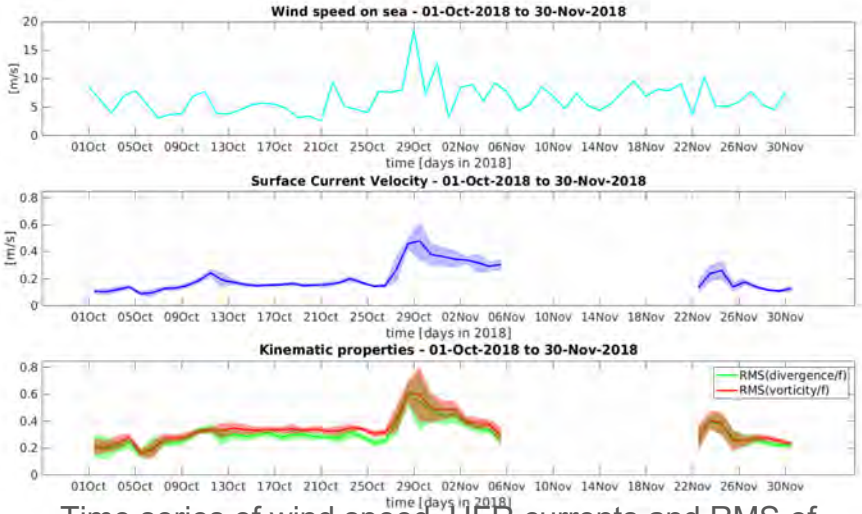


NEURAL operational coastal SOM-based forecasting system in the northern Adriatic (Vilibić et al., 2016)

HFR Applications: Extreme natural hazards

Extreme events

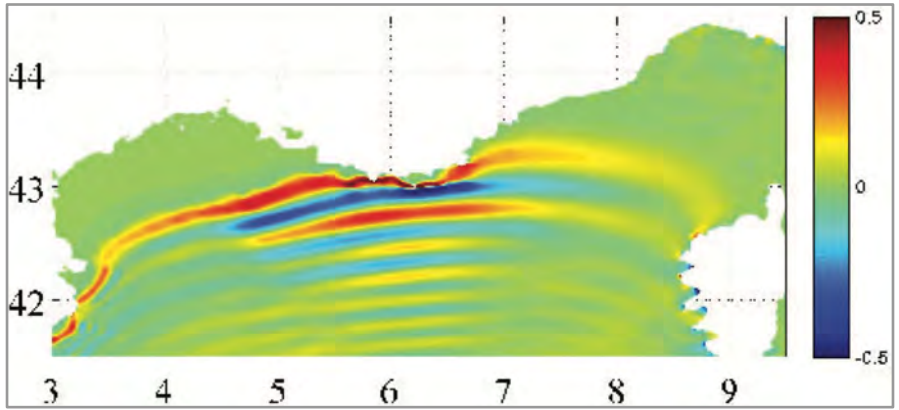
- Small-scale ocean response to extreme wind event.
- Extreme Ebro river freshwater discharge event.
- Sea state characterization during Gloria storm.
- Collapse of the Atlantic Jet in the Gibraltar strait.



Time series of wind speed, HFR currents and RMS of normalized vorticity & divergence during a extreme wind event in the Ligurian Sea in 2018 (Berta et al., 2020).

Tsunami detection

- HFR technology can detect tsunami-induced currents.
- Promising applications of HFRs.
- Integrated as complement tool to warning systems.
- Lower operational frequencies recommended.

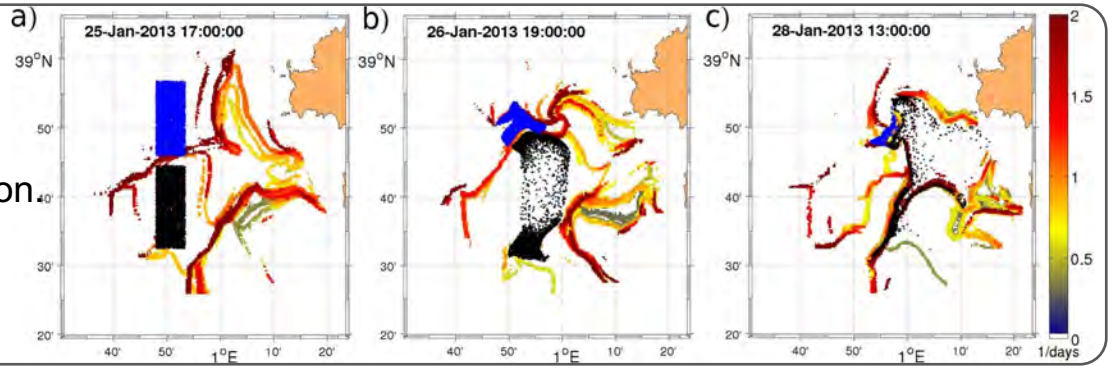


Simulated surface elevation (in meter) after 1h10 propagation for a tsunami generated by a M7.8 seismic source in the North of Algerian margin (courtesy of Stephan Grilli, Univ. of Rhode Island, USA).

HFR Applications: Ecological Transport Processes

Pollution and floatables tracking

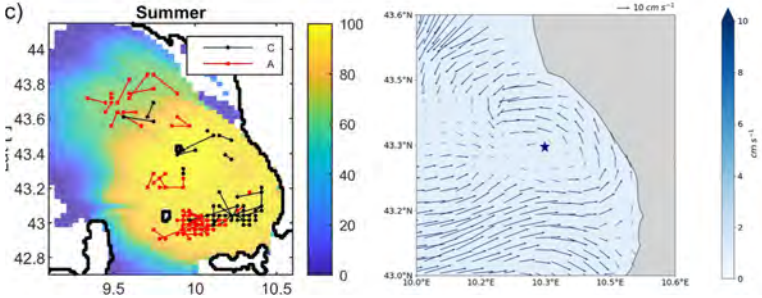
- HFR potential for tracking oil spills, ML
- To understand the phyto distribution.
- To identify scenarios that favour local retention.



Evolution of two sets of particles (black and blue) in the HFR-Ibiza footprint area superimposed on the backward FSLE (colorbar). Hernández-Carrasco et al., 2018

Eddy tracking

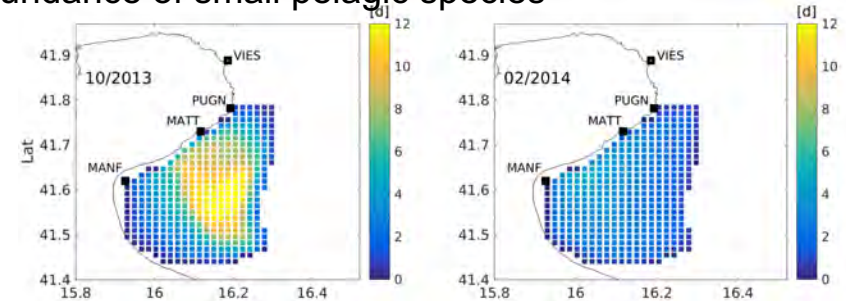
- 2 eddy algorithms tested in the Mediterranean
- To detect mesoscale eddies (Nencioli et al., 2010) and submesoscale eddies (Bagaglini et al., 2020)



Eddies detected with both algorithms with the HFR-LaMMA

Transport of biological quantities and connectivity

- HFR in support of the coastal zone management.
- To investigate oscillating plankton population dynamics, the role of coastal currents in the recruitment & abundance of small pelagic species



Average residence times (days) in the Gulf of Manfredonia.

Thank you very much for your attention



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